

Microcomb Fabrication Update

For Constellation-X Facility Science Team Meeting



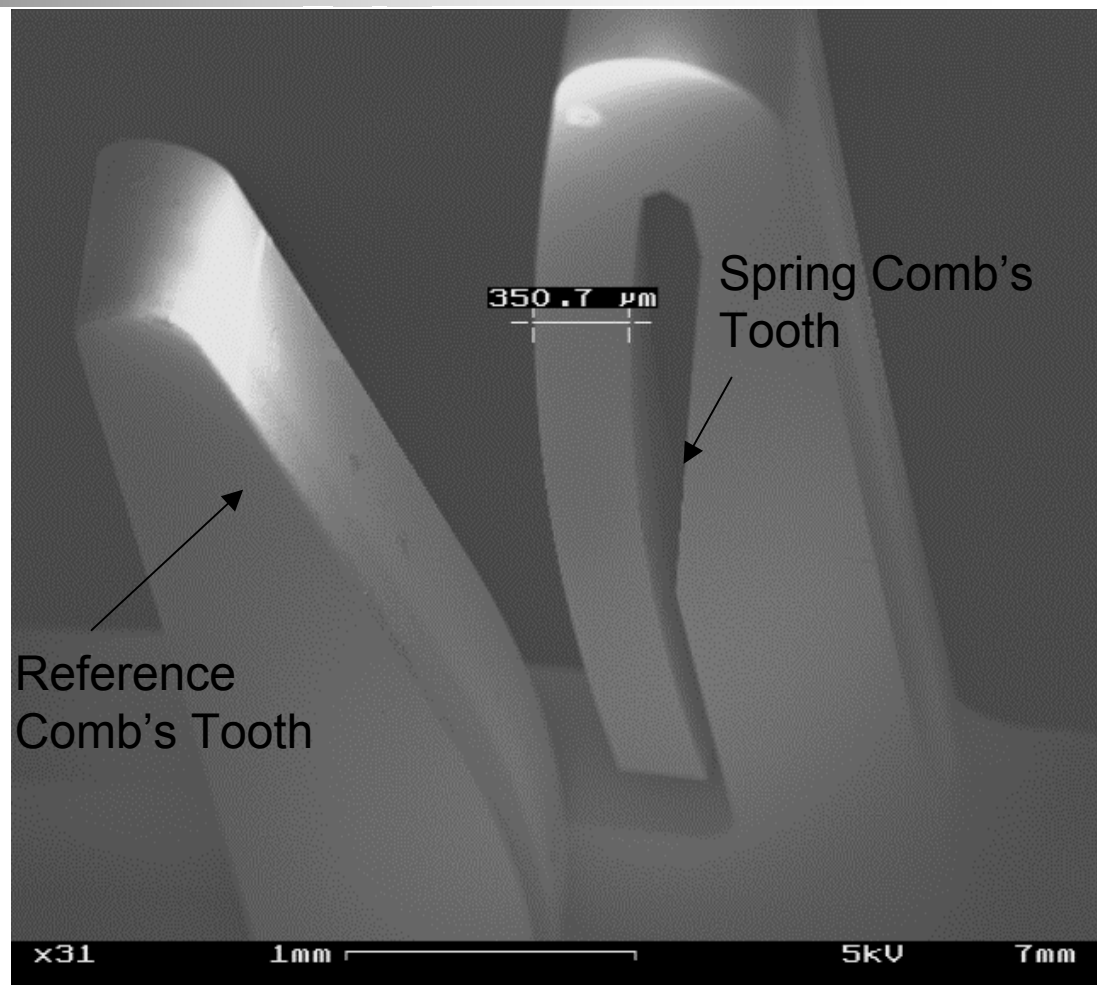
Space Nanotechnology Laboratory

Yanxia Sun, Ralf Heilmann, Carl Chen,
Craig Forest, Mark Schattenburg

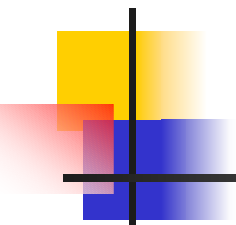
September 18, 2002

Microcomb for Precision X-ray Foils Assembly

- Accuracy requirement for reference comb;
- Previous fabrication process and problem;
- New 2-mask fabrication process.
- Future work: “Tall-teeth” microcomb for SXT



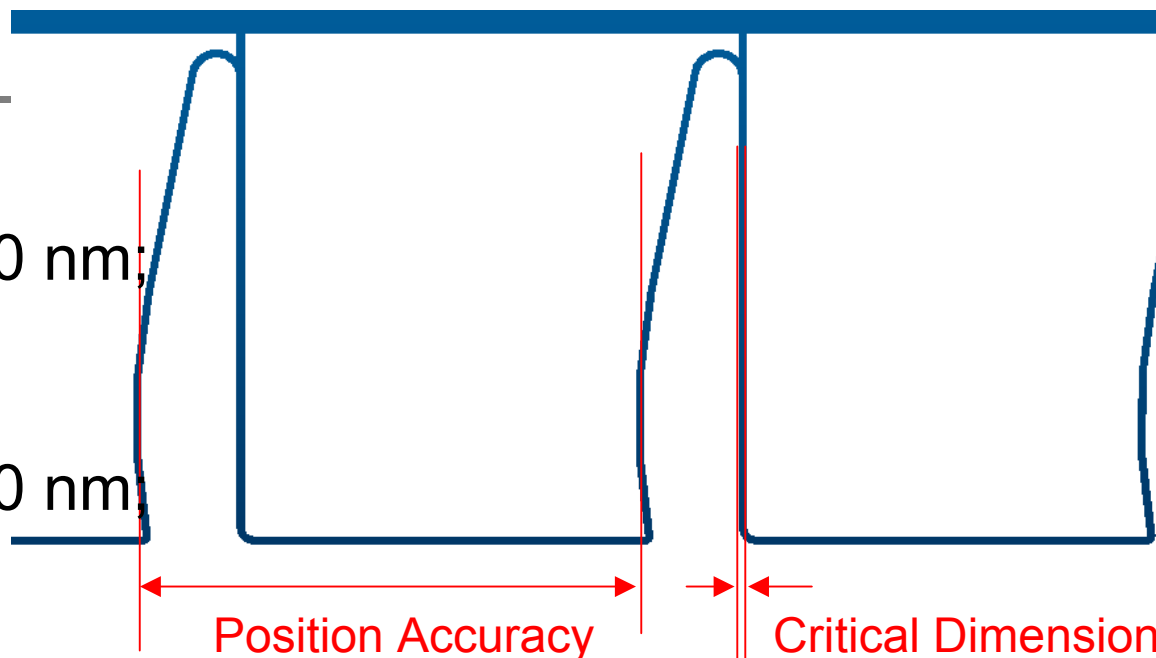
Accuracy requirement for Reference Comb



Position Accuracy:
Better than 100 nm;

Repeatability:
Better than 100 nm;

Critical Dimension:
Not specified;



Previous Fabrication Process

(a) DSP silicon wafer,
Thermal diffusion $2\ \mu\text{m}\ \text{SiO}_2$;



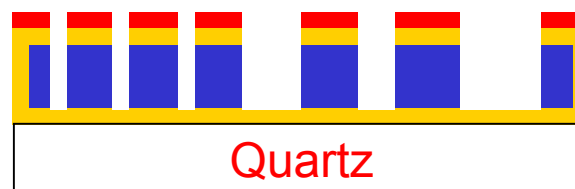
(b) Contact print thick PR;



(c) Etch SiO_2 ;



(d) DIRE with quartz handle-wafer, etch through;



(e) Strip PR, BOE, Extract finished microcomb;

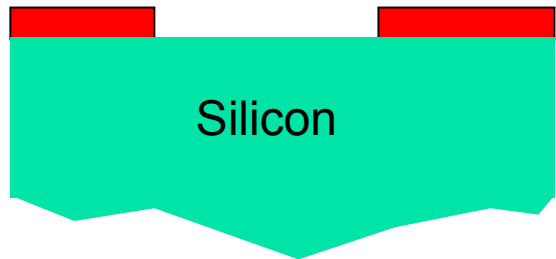


Legend:
Yellow square: SiO_2
Blue square: Si
Red square: PR
White square: Quartz

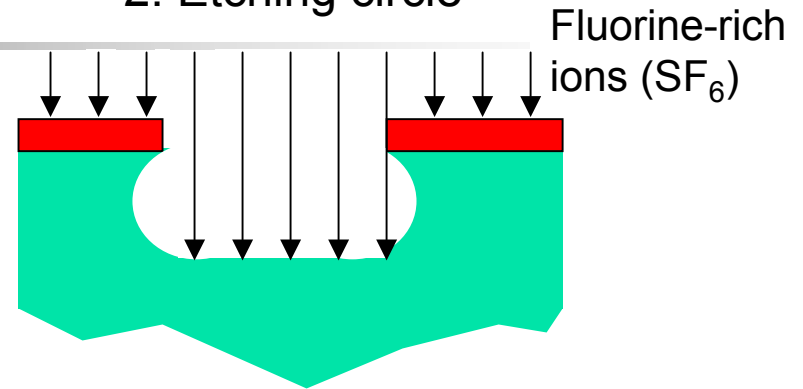
• 200 nm accuracy has been achieved based on 4 inch wafer process.

Deep Reactive Ion Etch for Silicon

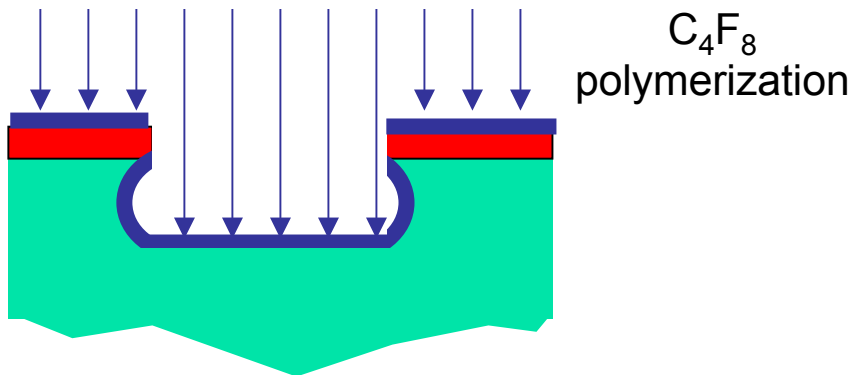
1. Substrate with etching mask



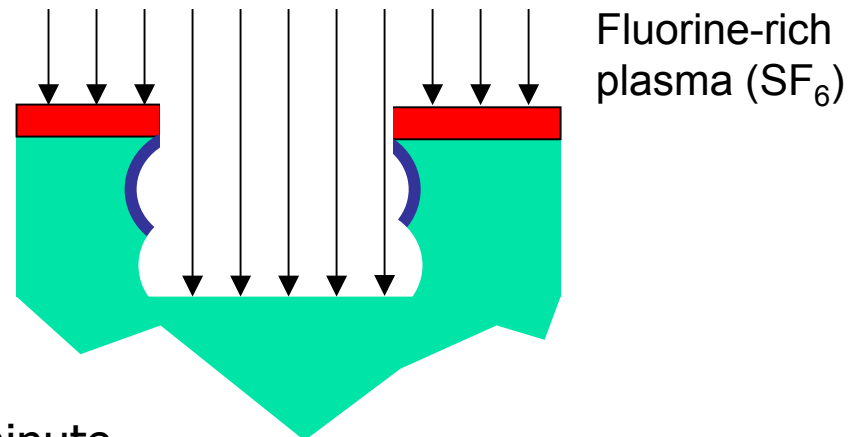
2. Etching circle



3. Polymer passivation circle



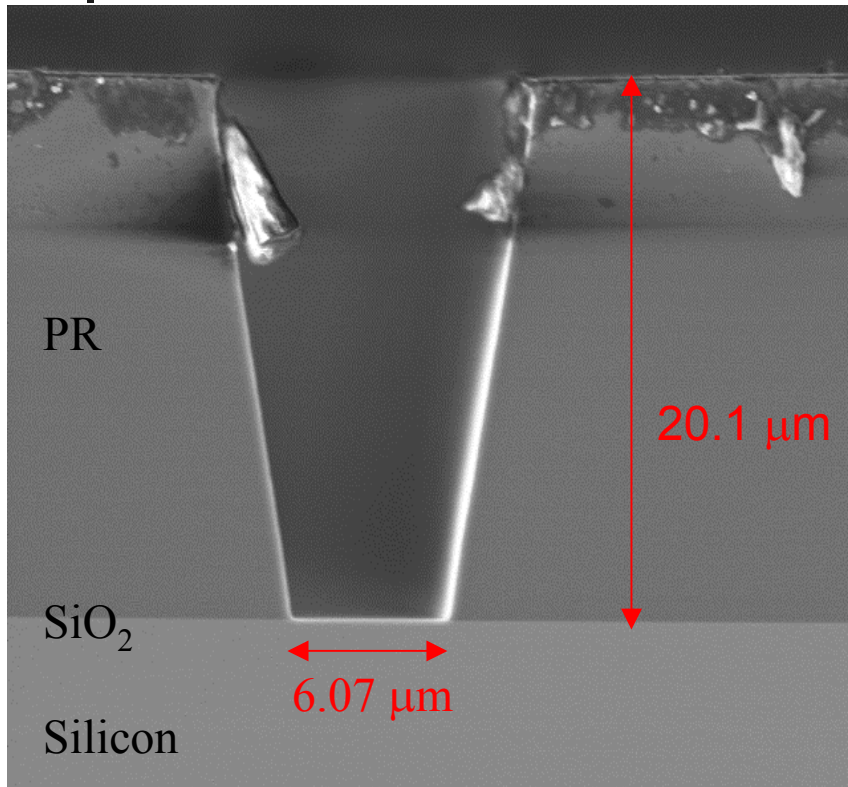
4. Etching circle



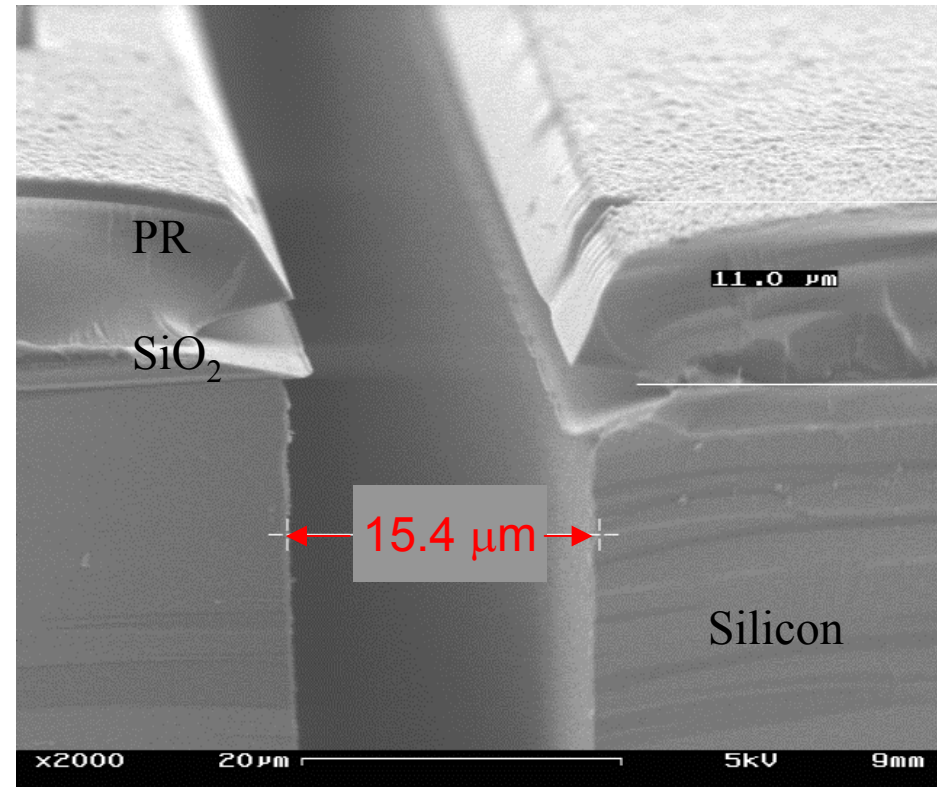
Etch rate is about 1~5 μm per minute.

Long-term Deep Reactive Ion Etch for Silicon

Thick Photoresist and oxide layer are required, which will introduce big CD loss and low repeatability.



Thick Photoresist Profile

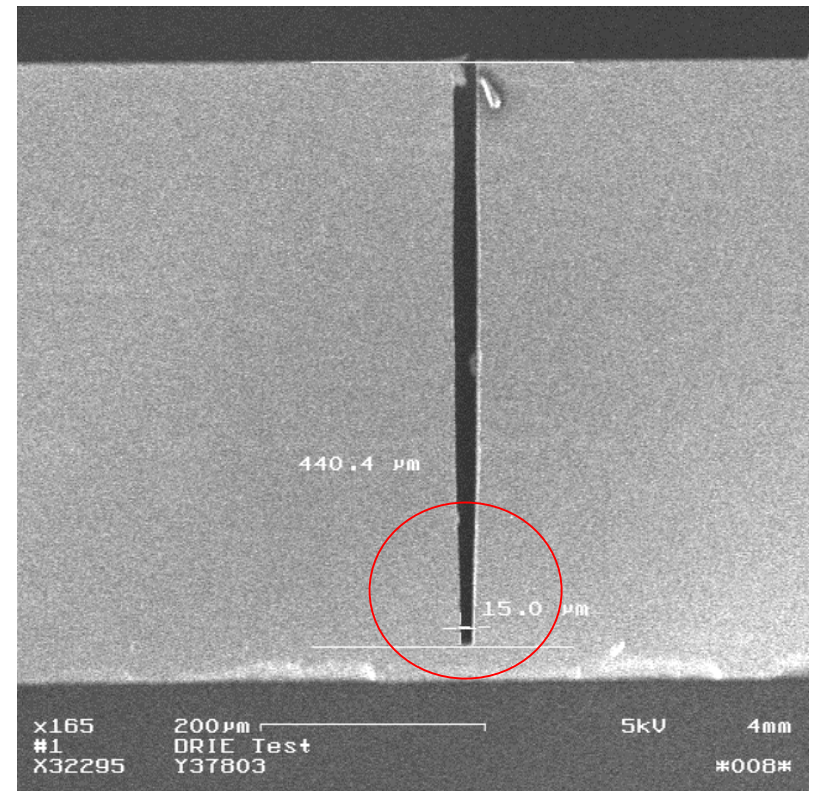
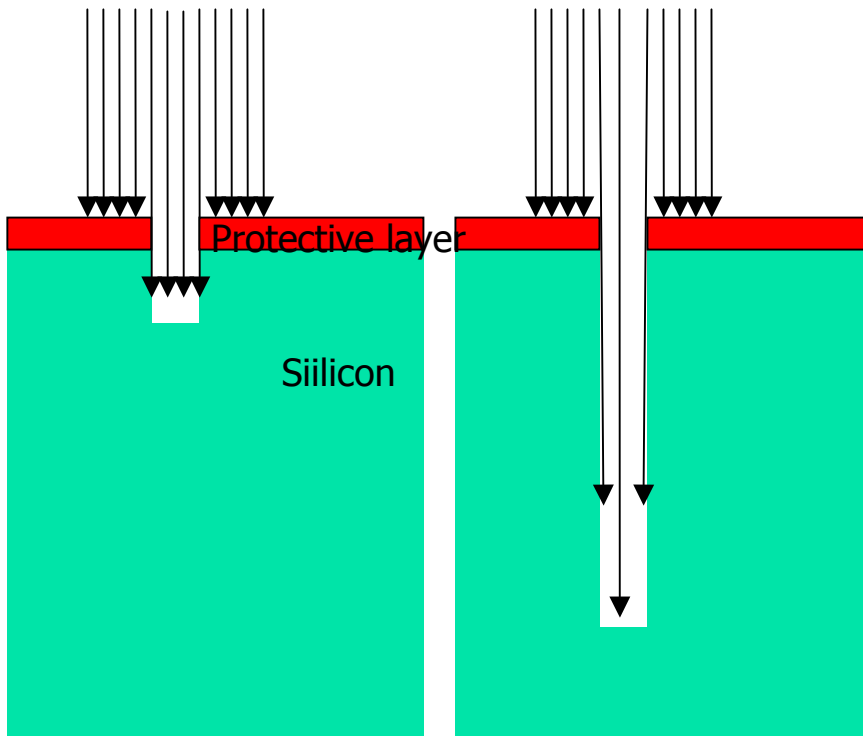


After 4.5 hour Deep Reactive Ion Etch for Silicon

Long-term Deep Reactive Ion Etch for Silicon

- The effect from angular ion distribution is amplified when etching deeper.

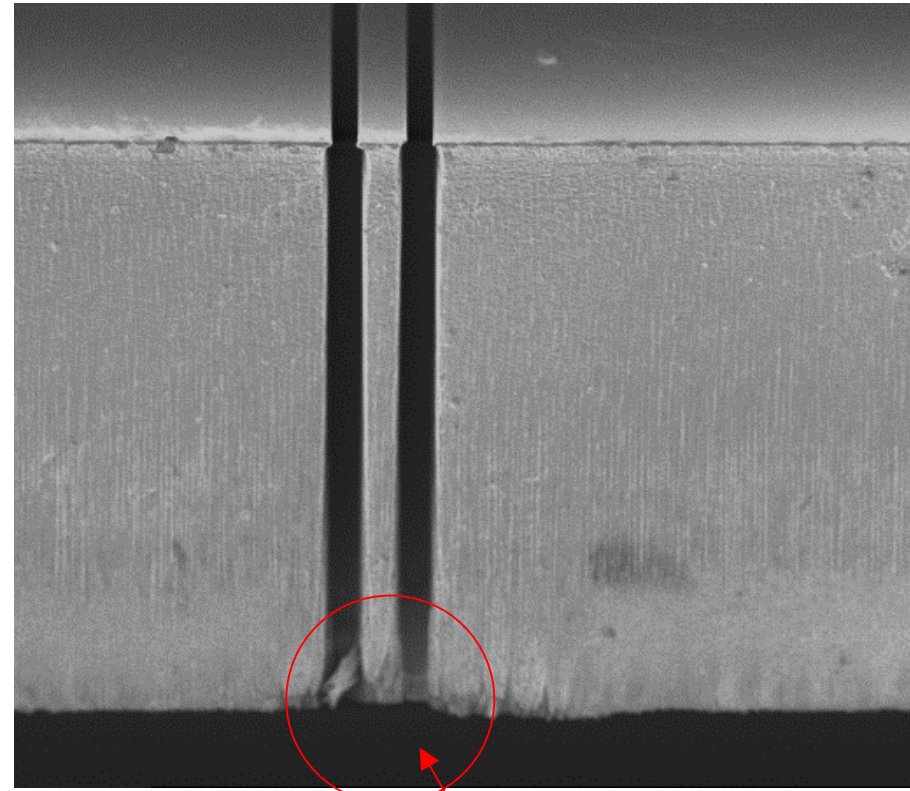
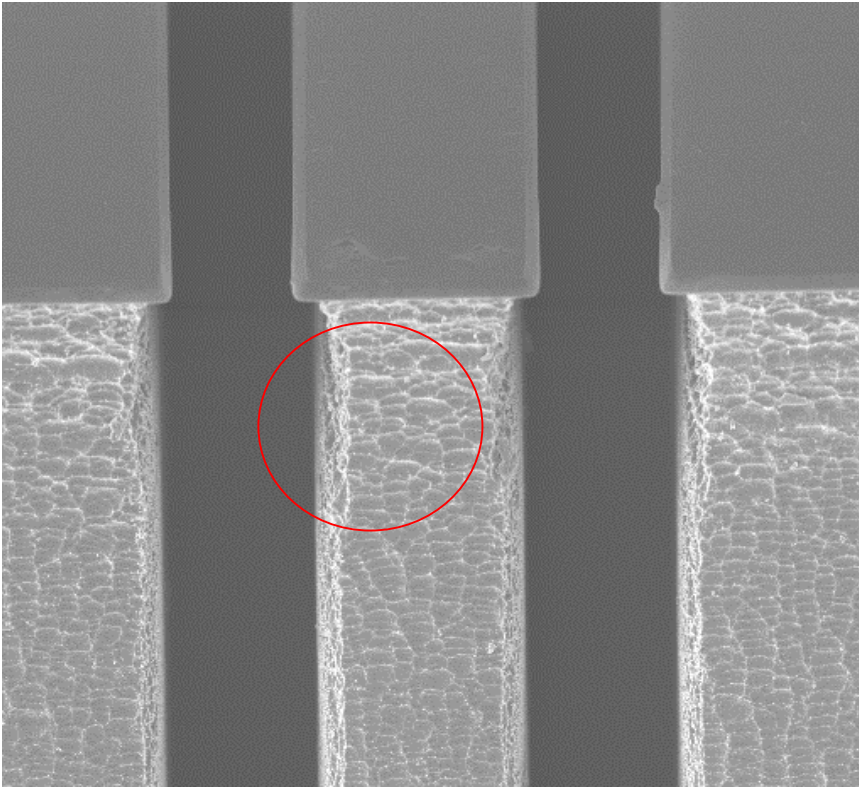
Ions:



Long-term Deep Reactive Ion Etch for Silicon

- Rough sidewall surface if overetching;

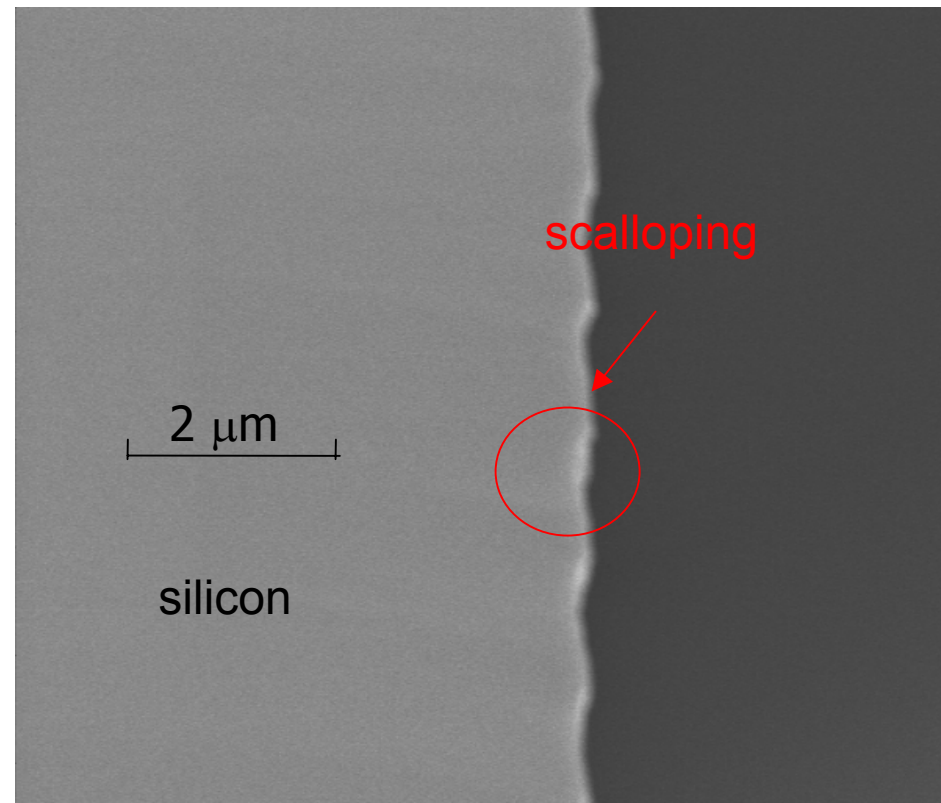
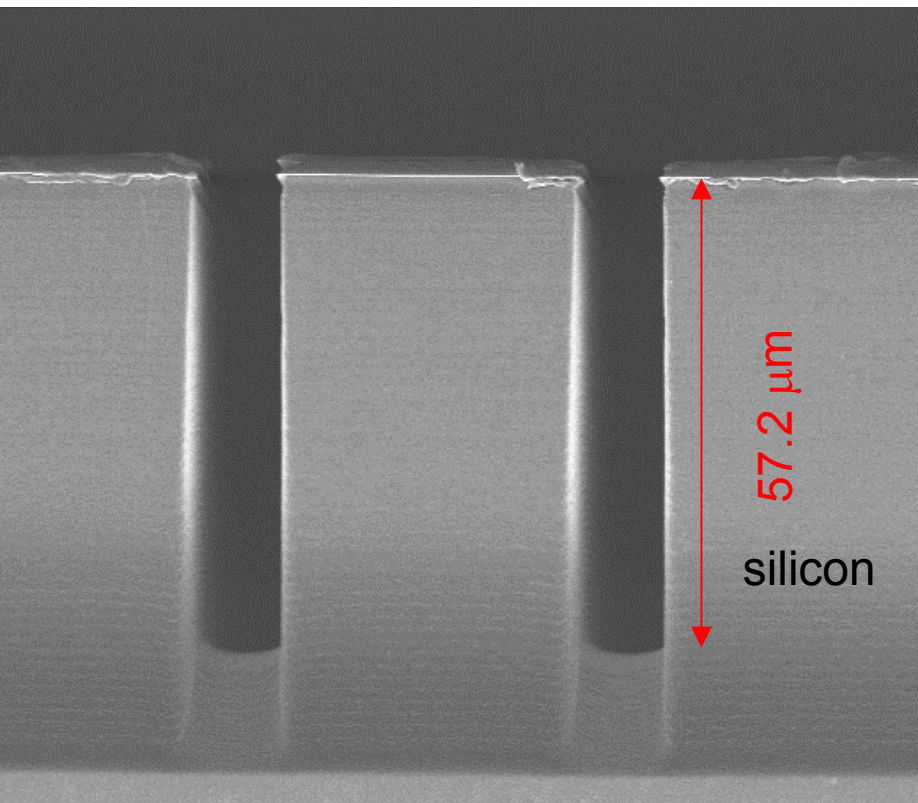
- Backside erosion when etching through;



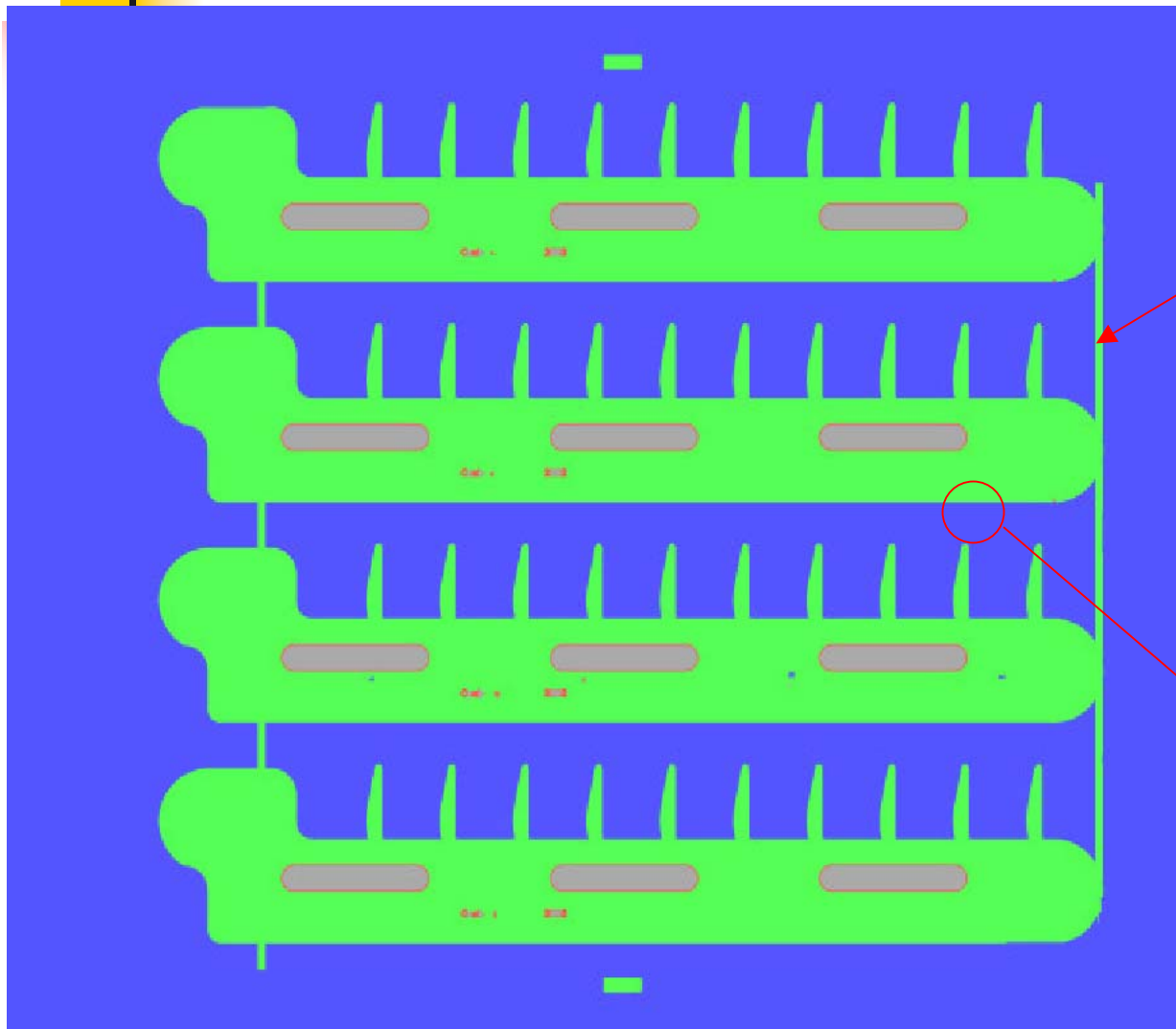
Backside erosion



20 minutes Deep Reactive Ion Etch for Silicon

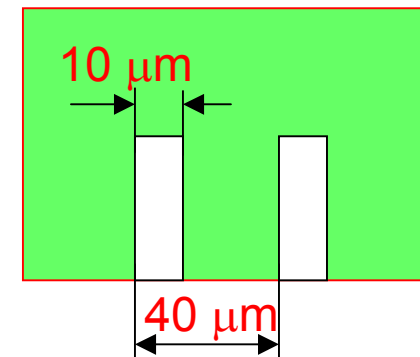


Mask Design

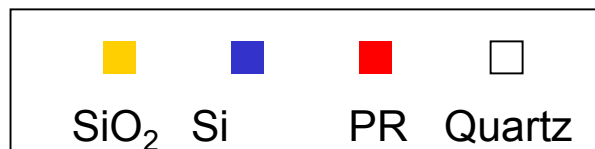


Connected bar to keep the combs on wafer after process

Reference lines to study the accuracy



Two-mask Process



(a) DSP silicon wafer,
Thermal diffusion 0.5~1 μm SiO₂;



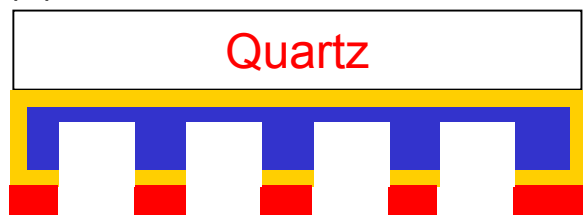
(b) Lithography for backside etch;



(c) Backside silicon dioxide etch;



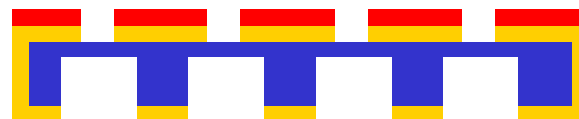
(d) Backside silicon etch, DRIE;



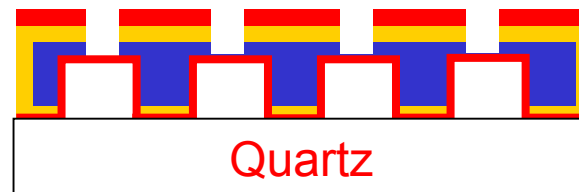
(e) Lithography for front side etch;



(f) Front side silicon dioxide etch;



(g) Front side silicon etch, DRIE
with backside protection with photoresist



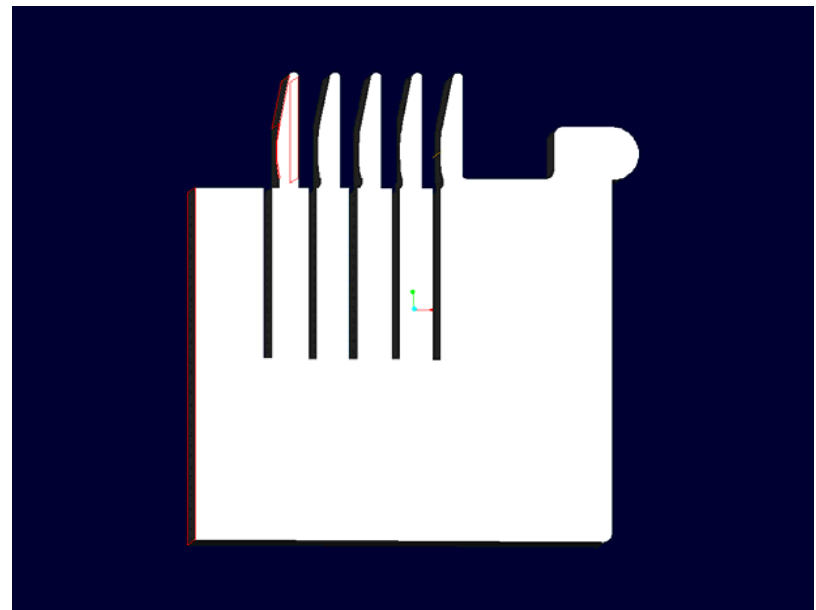
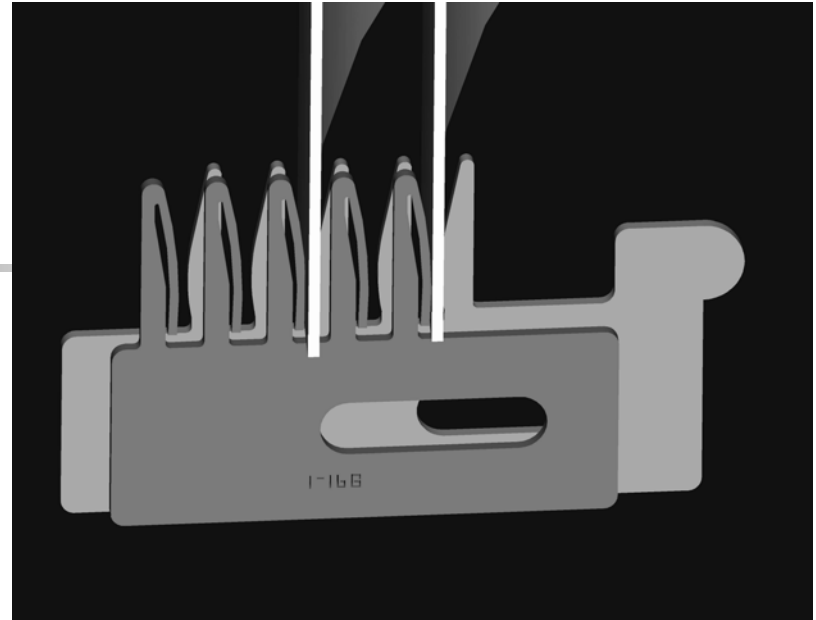
(h) Clean wafer, get comb out;



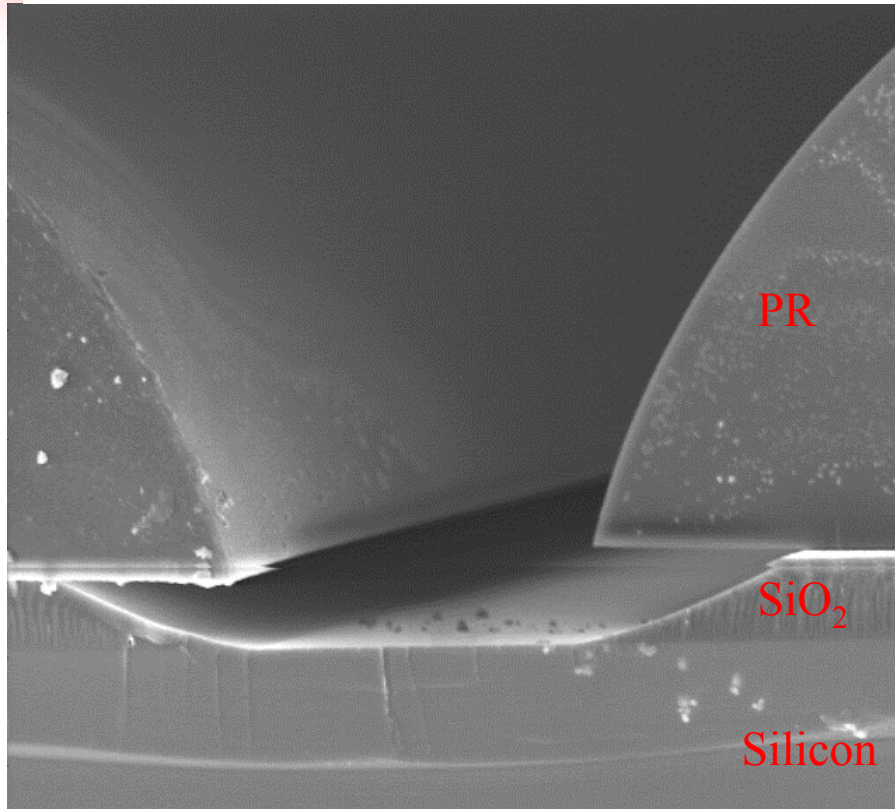


“Tall Teeth” Micro-comb

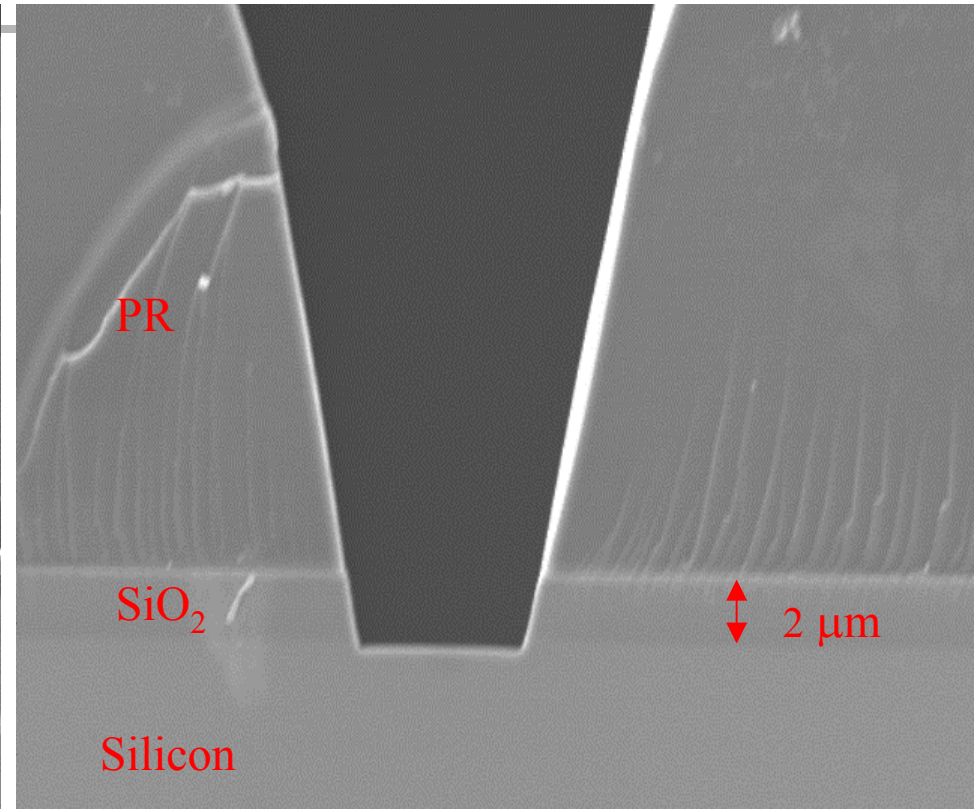
1. 10mm long reference tooth to avoid rough edge of the mirror;
2. EDM-cut metal strong-back bonded with silicon microcomb to stiffen reference tooth;



Etch Silicon Dioxide



SEM for Silicon oxide profile after BOE, 70 degree of sidewall angle.



•SEM for Silicon oxide profile after plasma etch, showing approximately sidewall angle of 7 degree.